

APPLICATION FOR  
UNITED STATES LETTERS PATENT  
SPECIFICATION

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Title of the invention

ANTENNA AND WRISTWATCH EQUIPPED WITH ANTENNA

[0001]

5 CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2003-18590, filed January 28, 2003, and the entire contents of which are incorporated herein by reference.

10

[0002]

BACKGROUND OF THE INVENTION

Field of the Invention

15 The present invention relates to an antenna and a wristwatch equipped with the antenna.

[0003]

Description of the prior art

20 There has been known a radio wave watch as a watch that displays the time accurately. The radio wave watch receives time information transmitted on radio waves for correcting the time, and displays the corrected accurate time. This watch has a built-in antenna for receiving the time informative radio waves. As shown in FIG. 13, an earlier developed antenna 70 is constructed by winding a conductor 25 72 as a coil around a bar-type magnetic body 71 formed of

ferrite. The receiving sensitivity of such antenna 70 is determined by the size of a wave receiving area, that is, by the area at both ends of the magnetic body 71. Therefore, in order to improve the wave receiving sensitivity of the antenna 70, it has been proposed to enlarge both ends of a magnetic body 81 of an antenna 80, as shown in FIG. 14, to expand the wave receiving area.

[0004]

However, several problems arise in using the ferrite-made magnetic body 81. Its mechanical fragility causes difficulty of manufacturing as the radio wave receiving areas at both ends of the magnetic body 81 are expanded, and also causes limitation of expanding the radio wave receiving area due to its low strength.

[0005]

#### Summary of the invention

An object of the invention is to provide an antenna and a watch equipped with this antenna which permit easier manufacturing even if a magnetic body has a larger radio wave receiving area.

In order to solve the problems mentioned above, in the present invention, an antenna main body having a conductor as a coil wound around a magnetic body and a radio wave

receiving part for receiving a radio wave are formed independently, an area of the radio wave receiving region of the radio wave receiving part is formed larger than a cross section of the antenna main body in a direction orthogonal to an axis line of the antenna main body, and the radio wave receiving part is arranged so as to be in contact with the antenna main body at an end in an axis line direction of the antenna main body.

10

[0006]

Brief description of the several views of the drawings

FIG. 1 is a schematic plan view of a wristwatch according to a first embodiment of the present invention.

FIG. 2 is a cross-sectional view taken along the line II-II of FIG. 1.

FIG. 3A is a schematic plan view of an antenna according to the first embodiment of the invention.

FIG. 3B is a schematic side view of a radio wave receiving part of an antenna according to the first embodiment of the invention.

FIG. 4A is a schematic plan view of an antenna according to modification 1 of the first embodiment of the invention.

FIG. 4B is a schematic side view of a radio wave receiving part of an antenna according to modification 1 of

the first embodiment of the invention.

FIG. 5A is a schematic plan view of an antenna according to modification 2 of the first embodiment of the invention.

FIG. 5B is a schematic side view of a radio wave  
5 receiving part of an antenna according to modification 2 of the first embodiment of the invention.

FIG. 6A is a schematic plan view of an antenna according to modification 3 of the first embodiment of the invention.

FIG. 6B is a schematic side view of a radio wave  
10 receiving part of an antenna according to modification 3 of the first embodiment of the invention.

FIG. 7A is a schematic view of an antenna according to modification 4 of the first embodiment of the invention.

FIG. 7B is a cross-sectional view taken along the line  
15 VIII-VIII of FIG. 7A.

FIG. 8A is a schematic plan view of an antenna according to modification 5 of the first embodiment of the invention.

FIG. 8B is a cross-sectional view taken along the line IX-IX of FIG. 8A.

20 FIG. 9 is a schematic plan view of a wristwatch according to a second embodiment of the invention.

FIG. 10 is a cross-sectional view taken along the line XI-XI of FIG. 9.

FIG. 11A is a schematic plan view of an antenna according  
25 to the second embodiment of the invention.

FIG. 11B is a schematic side view of a radio wave

receiving part of an antenna according to the second embodiment of the invention.

FIG. 12A is a schematic plan view of an antenna according to modification 1 of the second embodiment of the invention.

5        FIG. 12B is a cross-sectional view taken along the line XIII-XIII of FIG. 12A.

FIG. 13 illustrates an earlier developed antenna.

FIG. 14 illustrates another earlier developed antenna.

10

[0007]

Detailed description of the preferred embodiments

15        A detailed description will now be given of an antenna and a wristwatch equipped with the antenna according to the invention.

[First Embodiment]

20        As shown in FIGS. 1 and 2, an antenna 30 is built in a wristwatch 100, and receives time information on radio waves to correct the indicated time of the wristwatch 100.

25        The wristwatch 100 has a watch case 2 as a case body for containing a watch module 1 at the inside. The watch case 2 has a watch glass 3 mounted at the upper center via a packing 4. The watch module 1 has a frame member 5 which is arranged so as to contact with the watch glass 3 at the upper side. At the bottom of the case 2, there is attached a case back

6 via a waterproof seal 7, and a shock absorber 8 is provided between the module 1 and the case back 6. There is also provided a bezel 9 at the upper outer periphery of the case 2. Additionally, a watch band B is attached to the case 2 via band shafts 2A.

[0008]

The watch module 1 has an analog function. As shown in FIG. 2, the module 1 has an upper housing 10 and a lower housing 11 as intermediate members. A dial 12 is arranged at the upper surface of the upper housing 10, and the frame member 5 is disposed above the dial 12. Under the frame member 5, there is disposed a circuit board 13 as an electronic board interposed between the upper housing 10 and the lower housing 11 by a predetermined space. The module 1 is so constructed that the dial 12, upper housing 10, circuit board 13 and lower housing 11 are mounted on an inner frame 14 of the watch case 2.

The upper housing 10 is provided with an analog hand mechanism 15, and a battery (not shown) is embedded in the lower housing 11 for driving, for example, the hand mechanism 15 or the like.

[0009]

The upper housing 10 further includes an antenna 30.

The antenna 30 has, as shown in FIGS. 3A and 3B, a magnetic body 31 that is magnetized by radio waves, a conductor 34 wound around a part of the magnetic body 31 so

that current flows through the conductor 34 according to the intensity of magnetic field induced in the magnetic body 31 and the like.

5 The magnetic body 31 has radio wave receiving parts 32 for receiving time informative radio waves, and an antenna main body 33 which is formed independently of the radio wave receiving parts 32 and has the conductor 34 wound around on its surface.

10 The radio wave receiving part 32, which is formed of ferrite or the like and curved in a belt along the upper housing 10, is disposed on the upper housing 10. Each radio wave receiving part 32 has a concavity 132a formed thereon for coupling to the antenna main body 33. The radio wave receiving parts 32 are positioned opposing to each other with  
15 the antenna main body 33 placed between them, for example, at the three o'clock and the nine o'clock sides. The radio wave receiving parts 32 are coupled to the main body 33 by fitting both ends of the antenna main body 33 into the opposing respective concavities 132a. That is, the antenna main body  
20 33 is removably coupled to the receiving parts 32.

[0010]

The antenna main body 33 is provided so as to couple to the concavities 132a, and its both ends are supported on the upper housing 10 on which the wave receiving parts 32 are  
25 disposed.

The antenna main body 33 has the conductor 34, such as



a copper wire or the like, wound around on it. Radio waves magnetize the antenna main body 33 so that current flows in the conductor 34 depending on the intensity of the magnetic field produced in the magnetized antenna main body 33.

5 [0011]

The analog hand mechanism 15 includes a hand shaft 17 extending upward through a shaft hole 12a provided on the dial 12, and hands 18, such as an hour hand and a minute hand, mounted on the hand shaft 17, the hands 18 traveling above  
10 the dial 12. The dial 12 and the hands 18 have respective illuminating sections 19 at their predetermined positions, the illuminating sections 19 being illuminated by receiving the light from light emitting elements.

[0012]

15 The frame member 5 is formed of, for example, light-transmissible synthetic resin, particularly of transparent synthetic resin. As shown in FIG. 2, the frame member 5 is mounted on the inner surface of the watch case 2, touching the circumference of the lower surface of the watch glass 3  
20 and the circumference of the upper surface of the dial 12 (the upper housing 10). At predetermined positions on the frame member 5, for example, at the positions corresponding to the twelve o'clock and the six o'clock as shown in FIG. 1, there are arranged ultraviolet (UV) light emitting elements 201  
25 called black light. The frame member 5 arranged with the UV light emitting elements 201 also acts as a protection member

or a shock absorbing member. The UV light emitting element 201 is a UV lamp or UV light emitting diode (LED) or the like, which emits an ultraviolet ray having a wavelength of, for example, 254-420 nm (nanometer) or 374-389 nm, preferably  
5 about 365 nm.

[0013]

Referring back to FIG. 2, the UV light emitting element 201 is supported by a connecting member 21A, and is fixed. The connecting member 21A includes a contact member 21  
10 touching the UV light emitting element 201, and a coil spring 22 acting as an urging member for urging the contact member 21. The contact member 21 has a pair of support shafts 21a (one side only is shown in FIG. 2) corresponding to the electrodes (not shown) of the UV light emitting element 201,  
15 the shafts 21a being in contact with the respective electrodes.

[0014]

The contact member 21 having conductivity is, at its center portion, inserted into a through hole 10a provided on  
20 the upper housing 10, as well as a through hole 12b on the dial 12 and a through hole 5a on the frame member 5, and projected upward at the upper end portion of the frame member 5. This projected upper end (the pair of support shafts 21a) abuts against the UV light emitting element 201. There is  
25 provided a cushion 23 between the element 201 and the watch glass 3.

[0015]

The coil spring 22 having conductivity is inserted into the through-hole 10a, and elastically pushed against a connecting terminal T formed on the circuit board 13 at the lower end and against the lower end of the contact member 21 at the upper end. With this structure, the spring 22 urges the contact member 21 toward the UV light emitting element 201 to elastically support it. Further, the connecting member 21A including the contact member 21 and the spring 22 electrically connects the UV light emitting element 201 with the circuit board 13.

[0016]

The illuminating sections 19 are formed as resin parts, printed parts or painted parts at the predetermined positions on the dial 12 such as the upper surfaces of mark portions or hour numerals, and at the predetermined positions on the hands 18 in the analogue hand mechanism 15. It is preferable that the upper surfaces of the illuminating sections 19 are covered with transparent coating substance (not shown) for protection.

These illuminating sections 19 emit colored light, responding to the ultraviolet rays having the wave length of, for example, 350-420 nm or 254-365 nm, and remain transparent in normal state if not irradiated with ultraviolet rays. That is, the illuminating sections 19 emit colored light responding to the ultraviolet rays emitted from the UV

emitting element 201 or to the ultraviolet rays passed through the light transmissible frame member 5.

[0017]

According to the antenna 30 in the embodiment, the  
5 antenna main body 33 and the radio wave receiving parts 32 are formed independently, so that both of the antenna main body 33 and the radio wave receiving part 32 can be formed in simple shapes, whereby manufacturing of the entire magnetic body becomes easier even if the area of the radio  
10 wave receiving region of the radio wave receiving part 32 is expanded. Additionally, since partially loaded positions do not exist, the mechanical strength of the antenna 30 is improved. In other words, the area of the radio wave receiving region of the radio wave receiving part 32 can be  
15 formed larger than the cross sectional area of the main body 33 in a direction orthogonal to an axis line of the antenna body 33 (a winding direction of the conductor 34 wound around the antenna main body 33), so that radio wave receiving sensitivity can be improved, and directivity can be moderated  
20 due to the increase of receivable directions.

[0018]

Next, a description will be given of modifications of the antenna 30 in the first embodiment described above.

<Modification 1>

25 Referring to FIGS. 4A and 4B, in an antenna 30a according to modification 1, a radio wave receiving part 32a has a groove

portion 35a formed thereon, and an antenna main body 33a has protrusions 36a at its both ends to fit into the respective groove portions 35a. The groove portion 35a is formed such that, when the radio wave receiving part 32a is placed on the upper housing 10, the groove 35a extends from the upper side of the wristwatch 100 to the lower side so that the protrusions 36a of the antenna main body 33a can fit into the grooves 35a to construct the antenna 30a. The antenna main body 33a includes a conductor 34a wound around like a coil on its surface.

[0019]

With this structure, the antenna main body 33a can be attached to the radio wave receiving part 32a after the radio wave receiving part 32a is mounted on the upper housing 10, which increases flexibility in manufacturing. Further, the main body 33a can be pulled out along the groove 35a when it is removed, leading to easier removing operation.

[0020]

<Modification 2>

Referring to FIGS. 5A and 5B, an antenna 30b in accordance with modification 2 differs from the modification 1 in that a radio wave receiving part 32b is changed to near L-shaped one instead of the arc-shaped radio wave receiving part 32a.

Two radio wave receiving parts 32b are arranged symmetrical about the center position on the upper surface

of the wristwatch 100, each part having a groove portion 35b formed thereon, and an antenna main body 33b has protrusions 36b at its both ends to fit into the respective groove portions 35b. The groove 35b is formed such that, when the radio wave receiving part 32b is placed on the upper housing 10, the groove 35b extends from the upper side of the wristwatch 100 to the lower side so that the protrusions 36b of the main body 33b can fit into the grooves 35b to construct the antenna 30b. The antenna main body 33b includes a conductor 34b wound around like a coil on its surface.

[0021]

Such a structure achieves the same effect as those in the modification 1, and further, two radio wave receiving parts 32b form a near rectangular periphery. Therefore, the antenna 30b is applicable to a rectangular watch.

[0022]

#### <Modification 3>

Referring to FIGS. 6A and 6B, in an antenna 30c according to modification 3, both ends of an antenna main body 33c are formed in saw-toothed shape having continuous ridge portions and valley portions, and so are the connection parts of radio wave receiving parts 32c, the ridge portions and valley portions of the antenna body 33c and the radio wave receiving parts 32c engaging with each other.

[0023]

With this structure, the contact surface between the

radio wave receiving part 32c and the antenna main body 33c is larger than that in the modification 1 or modification 2, so that the friction of the connecting position resultantly increases. This friction increase keeps the antenna 30c more  
5 stable, and stabilizes the sensitivity of receiving radio waves.

[0024]

<Modification 4>

Referring to FIGS. 7A and 7B, in an antenna 30e according  
10 to modification 4, the arc-shaped radio wave receiving parts 32 of the first embodiment are formed on the circuit board 13 as a pattern, and the antenna main body 33 is removably attached to the circuit board 13.

Radio wave receiving parts 32e are formed as a pattern  
15 at two positions on the circuit board 13 with copper foil or the like, and a mounting hole H is formed between the receiving parts 32e for attaching an antenna main body 33e thereto. The main body 33e is fit into the mounting hole H to construct the antenna 30e.

20 [0025]

Such a structure makes the thickness of the antenna 30e thinner than the main body 33e by that of the circuit board 13. Application of this thinner antenna 30e can make the wristwatch 100 thinner.

25 [0026]

<Modification 5>

As shown in FIGS. 8A and 8B, an antenna 30f in accordance with modification 5 includes radio wave receiving parts 32f formed by copper foil or the like as a pattern at two positions on a film substrate F, and an antenna main body 33f comprising a film-type coil element disposed between the receiving parts 32f. The antenna main body 33f includes two sheets of base films 50a and 50b bonded each other with adhesive 51, each sheet made of synthetic resin such as polyethylene terephthalate (PET) or poly-vinyl chloride (PVC), and a film dielectric 52 embedded between the base films 50a and 50b. Over the surfaces of the base films 50a and 50b, there are provided thin film conductors 53a and 53b made of copper foil or the like adhered to the respective base films 50a and 50b with adhesive 51. These thin film conductors 53a and 53b, confronting each other and sandwiching the dielectric 52, are connected with conductive through holes 54. The thin film conductor 53 connected with the through holes 54 is spirally wound around the dielectric 52 to form a pseudo-coil having the dielectric 52 as a core substance.

[0027]

With such a structure, the antenna 30f can be constructed much thinner than the antenna 30e having, as shown in FIG. 7A, the antenna main body 33e attached to the circuit board 13. Application of this thinner antenna 30f can make the wristwatch 100 much thinner.

[0028]



## [Second Embodiment]

Referring to FIGS. 9 and 10, an antenna 40 in accordance with a second embodiment is embedded within a wristwatch 200, and receives time information on radio waves to correct the indicated time of the wristwatch 200. Meanwhile, the same elements as those in the first embodiment are designated by the same reference numerals and the description thereof is omitted.

The antenna 40, as shown in FIGS. 11A and 11B, has a magnetic body 41 magnetized by the radio waves, and a conductor 44 wound around the magnetic body 41, through which current flows depending on the intensity of magnetic field induced in the magnetic body 41.

The magnetic body 41 includes an antenna main body 43 having a conductor 44 wound around thereon, radio wave receiving parts 42 formed independently of the antenna main body 43 for receiving radio waves, and the like. The second embodiment differs from the first embodiment in that the radio wave receiving parts 42 are arranged apart from the antenna main body 43.

The radio wave receiving part 42 made of magnetic substance such as ferrite is, as shown in FIG. 10, disposed within a containing space S formed by the watch case 2 and the inner frame 14, being curved in a belt along the watch case 2 and the inner frame 14. The radio wave receiving parts 42 are arranged at opposing positions to each other such as,

for example, the three o'clock and the nine o'clock positions, respectively, each part being spaced apart from the end of the antenna main body 43.

[0029]

5           The antenna main body 43 made of magnetic substance such as ferrite is disposed between the opposing radio wave receiving parts 42, and supported on the upper housing 10 at its both ends.

10           The antenna main body 43 has a coil-like conductor 44 wound around thereon. With this structure, the radio wave caught by the radio wave receiving parts 42 magnetizes the antenna main body 43, which creates induction current on the conductor 44 according to the intensity of the magnetic field.  
[0030]

15           In the antenna 40 of the embodiment, the antenna main body 43 and the radio wave receiving parts 42 are formed independently, which permits the antenna body 43 and the radio wave receiving parts 42 to be formed in simple shapes, and therefore manufacturing of an entire magnetic body becomes  
20           easier even if the radio wave receiving parts 42 have large area of the radio wave receiving region of the radio wave receiving parts 42. Furthermore, without partially loaded position, the mechanical strength of the antenna 40 can be improved. Accordingly, compared with an earlier developed  
25           antenna, each radio wave receiving part 42 can have much larger area of the radio wave receiving region than the cross

sectional area of the antenna main body 43 in the direction orthogonal to the axis line of the antenna main body 33 (the winding direction of the conductor 44 wound around the antenna main body 33). This larger receiving area allows improving  
5 the sensitivity of receiving radio waves, and also moderate directivity due to the increase of receivable directions.

Additionally, since the radio wave receiving parts 42 are arranged apart from the antenna main body 43, the layout flexibility of the antenna 40 can be improved. This  
10 flexibility allows the antenna to be favorably applied to small-sized electronic devices, such as the wristwatch 200, that require a limited occupying space.

[0031]

<Modification 1>

15 Referring to FIGS. 12A and 12B, in an antenna 40a according to modification 1, the arc-shaped radio wave receiving parts 42a of the second embodiment are formed on the circuit board 13 as a pattern, and the antenna main body 43 is removably attached to the circuit board 13.

20 Radio wave receiving parts 42a are formed as a pattern at two positions on the circuit board 13 with copper foil or the like, and a mounting hole H is formed between the receiving parts 42a for attaching an antenna main body 43a. The antenna main body 43a is fit into the mounting hole H to construct  
25 the antenna 40a.

[0032]

Such a structure makes the thickness of the antenna 40a thinner than the antenna main body 43a by that of the circuit board 13. Application of this thinner antenna 40a can make the wristwatch 200 thinner.

5 [0033]

The present invention is not limited to the embodiments described above. For instance, an antenna may be built in a digital wristwatch as well as an analog wristwatch. Various changes may also be made in the shape and arrangement of radio  
10 wave receiving parts and an antenna main body.

Other variations and modifications may be made without departing from the scope of the invention.

[0034]

According to the present invention, the antenna main  
15 body and the radio wave receiving parts are formed independently, which permits the antenna body and the radio wave receiving parts to be formed in simple shapes, and therefore manufacturing of an entire magnetic body becomes easier even if the radio wave receiving parts have large areas  
20 of the radio wave receiving regions. Furthermore, without partially loaded position, the mechanical strength of the antenna can be improved. Accordingly, compared with an earlier developed antenna, each radio wave receiving part can have much larger area of the radio wave receiving region than  
25 the cross sectional area of the antenna main body in the direction orthogonal to the axis line of the antenna main body

33 (the winding direction of the conductor 34 wound around the antenna main body 33). This larger receiving area allows improving the sensitivity of receiving radio waves, and also moderate directivity due to the increase of receivable  
5 directions.

[0035]

Since the radio wave receiving parts are arranged apart from the antenna main body, the layout flexibility of the antenna can be improved. This flexibility allows the antenna  
10 to be favorably applied to small-sized electronic devices, such as the wristwatch, that require a limited occupying space.

[0036]

Since the radio wave receiving parts are formed on the  
15 circuit board as a pattern, which allows the radio wave receiving parts to be thin, thereby making the antenna thinner.

[0037]

Since the radio wave receiving parts are arranged apart  
20 from the antenna main body, the layout flexibility of the antenna can be improved. This flexibility allows the antenna to be favorably applied to small-sized electronic devices, such as the wristwatch, that require a limited occupying space.

25 [0038]

Further, by building in the antenna of the present

invention, the wristwatch which has improved radio wave receiving sensitivity, and in which directivity can be moderated due to the increase of receivable directions can be provided.